

CAPT Science Performance Task

Slipping and Sliding

A manufacturer of large pieces of heavy and fragile equipment transports them by ship. The equipment is often damaged by boxes sliding into one another. Is there anything that can be done to keep the boxes from sliding? The manufacturer would like to increase the amount of friction between the boxes and the floor of the ship without changing the material on the surface of the boxes.

Your Task

Friction is a force opposing the relative motion of two objects that are in contact with each other. A number of different variables may affect the amount of friction between two objects. These variables may include the types of surface materials in contact with each other, the weight of the object, and the surface area between the objects. You and your partner will design and conduct an experiment to study the effect of one or more of these variables on the amount of friction between two objects.

During this activity you will work with a partner (or possibly two partners). However, you **must** keep your own individual lab notes because after you finish you will work **independently** to write a report about your investigation.

You have been provided with the following materials and equipment. It may not be necessary to use all of the equipment that has been provided. You may use additional materials and equipment if they are available.

1 wooden dowel	20 small washers
1 wooden block	3 large washers (for adding weight to the block)
1 piece of cardboard	Plastic cup to hold washers
1 sheet of coarse sandpaper	Ruler
1 sheet of fine sandpaper	Masking tape
1 piece of wax paper	1 paper clip
String	Safety goggles for each student

Steps to Follow

1. **In your own words, clearly state the problem you are going to investigate.** Include a clear identification of the independent and dependent variables that will be studied. Write your statement of the problem in the space provided.
2. The instructions on the next page show one way to measure the amount of friction between a wooden block and different surfaces. **Using these instructions, design an experiment to solve the problem.** Your experimental design should match the statement of the problem, should control for variables, and should be clearly described so that someone else could easily replicate your experiment. Include a control if appropriate.

Write your experimental design in the space provided. Show your design to your teacher before you begin your experiment.

Note: Your experiment should be done on the cardboard to avoid scratching tables or desks.

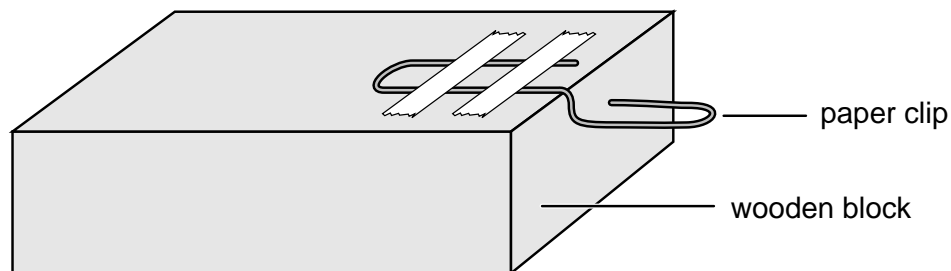
3. **After receiving approval from your teacher, work with your partner to carry out your experiment.** Your teacher's approval does not necessarily mean that your teacher thinks your experiment is well designed. It simply means that in your teacher's judgment your experiment is not dangerous or likely to cause an unnecessary mess.
4. **While conducting your experiment, take notes on the attached pages.** Include the results of your experiment. Tables, charts and/or graphs should be used where appropriate and should be properly labeled. Space for your data is provided.

Your notes will **not** be scored, but they will be helpful to you later as you work independently to write about your experiment and results. You must keep your own notes because you will not work with your partner when you write your lab report.

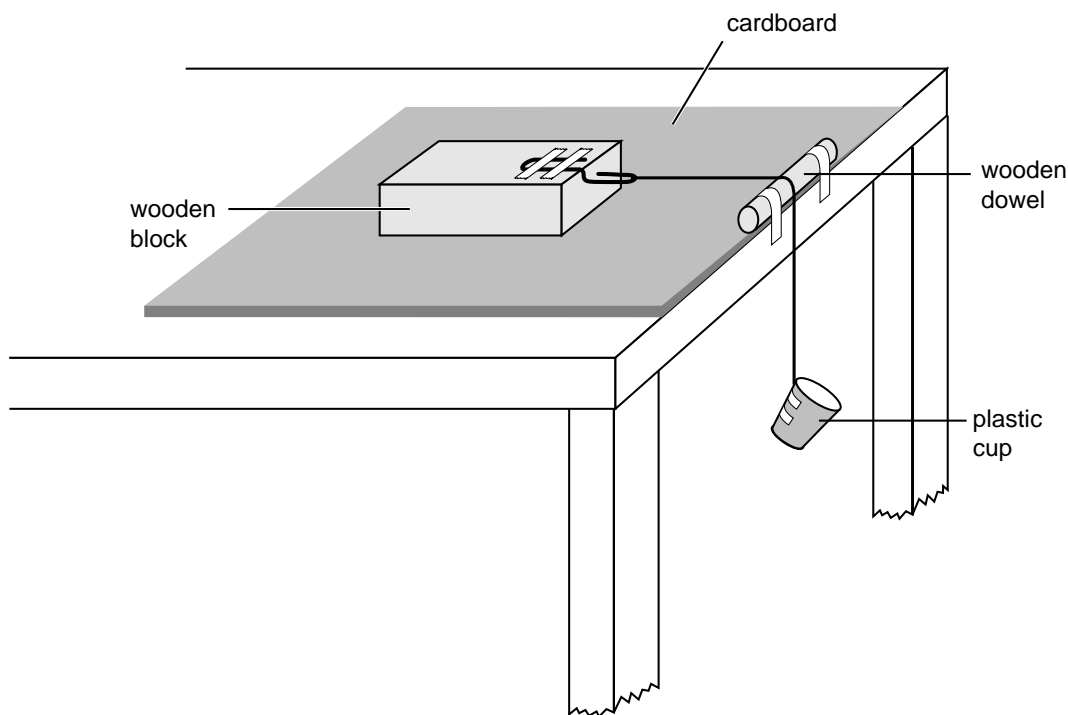
When you have finished, your teacher will give you instructions for clean up procedures, including proper disposal of all materials.

Instructions for Measuring the Amount of Friction

1. Unfold and bend the paper clip and tape it to one end of the wooden block as shown below. The wooden block represents the shipping box.



2. Tie one end of the string to the paper clip. Tape the other end of the string to the plastic cup. Tape the wooden dowel to one end of the cardboard. Place the string over the wooden dowel and hang the plastic cup over the end of your table or desk. (See the diagram below.)
3. To measure the amount of friction between the wooden block and the surface, add small washers to the plastic cup. The number of washers required to move the wooden block provides a quantitative measure of the amount of friction.



(Students are provided with four blank pages for their notes, as well as a grid for tables, charts or graphs.)

Directions for Writing Your Laboratory Report

Working on your own, summarize your experiment and results. You may use your own notes that you took previously while working with your partner. You may wish to write a first draft of your lab report on scratch paper. Space for your final report is provided on the following pages in this booklet. You will have approximately 30 minutes to complete your report.

Your report should include the following:

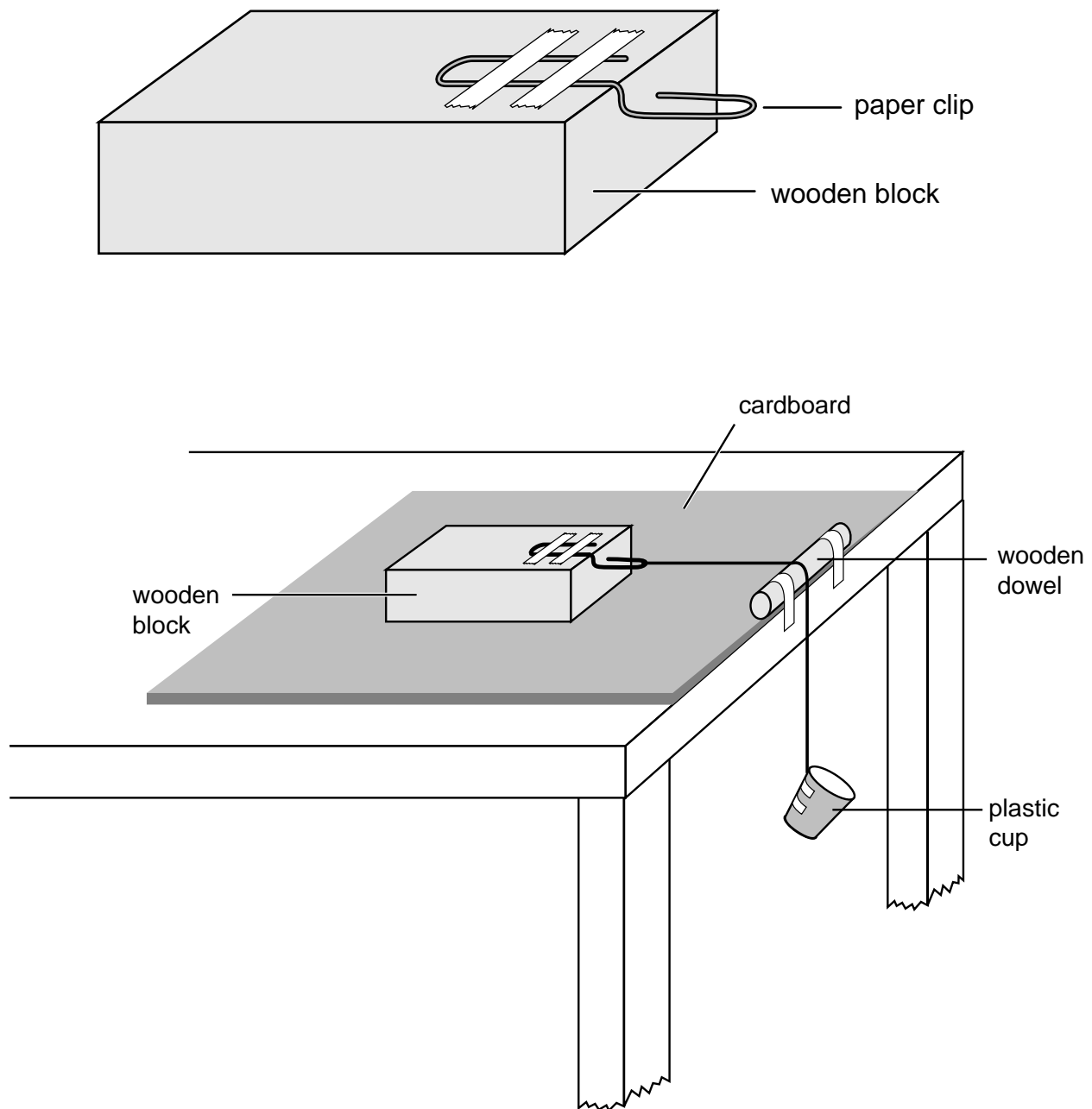
- ☐ **A clear statement of the problem you investigated.** Include a clear identification of the independent and dependent variables that were studied.
- ☐ **A description of the experiment you carried out.** Your description should be clear and complete enough so that someone else could easily replicate your experiment.
- ☐ **The results of your experiment.** Tables, charts and/or graphs should be used where appropriate and should be properly labeled. Space for your data is provided.
- ☐ **Your conclusions from the experiment.** Your conclusions should be fully supported by data.
- ☐ **Comments about how valid you think your conclusions are.** In other words, how much confidence do you have in your results and conclusions? Any factors that contribute to a lack of confidence in the results or conclusions should be discussed. Also, include ways that your experiment could be improved if you were to do it again.

(Students are provided with four lined pages for their reports, as well as a grid for tables, charts or graphs.)

CAPT Experimentation Questions

Slipping and Sliding

Students in a science class were conducting experiments to study the effect of different variables on the amount of friction between two objects. The diagram below shows the apparatus used by the students to measure the amount of friction.



Group A carried out the following experiment:

1. In our experiment we compared different types of materials to see which one provided the most friction.
2. We compared coarse sandpaper, fine sandpaper, wax paper and cardboard while pulling a wooden block across each material.
3. We added five washers at a time to the plastic cup in order to make the block move. Our results are shown in the table below.

Group A used the apparatus shown on page 11.

Movement of Wooden Block When Small Washers Are Added

		Material over which Wooden Block Slides			
		Cardboard	Wax Paper	Fine Sandpaper	Coarse Sandpaper
Number of Small Washers Added to Cup	0 Washers	None	None	None	None
	5 Washers	Moved	Moved	None	None
	10 Washers			Moved	None
	15 Washers				Moved

1. Group A concluded that cardboard and wax paper both created the same amount of friction with the wooden block. Is this conclusion valid? Explain your answer fully.

Group B carried out the following experiment:

To increase the weight of the block, we placed large washers, one at a time, on top of the wooden block. We did this for each of the four materials and then measured the friction. The table below shows our results.

Number of Small Washers Required to Move Block

		Number of Large Washers Added to Block		
		1 Large Washer	2 Large Washers	3 Large Washers
Material	Cardboard	5	9	12
	Wax Paper	6	9	11
	Fine Sandpaper	10	15	24
	Coarse Sandpaper	9	14	22

Group C carried out the following experiment:

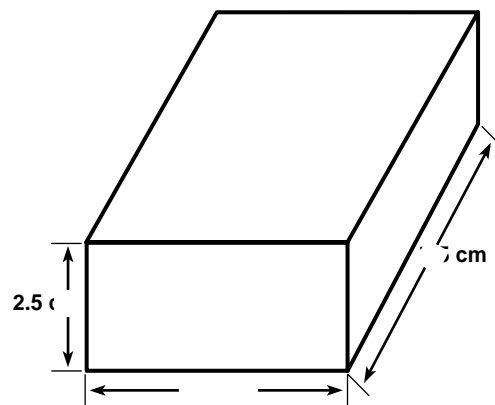
We placed a wooden block with one large washer on top of a piece of cardboard. We counted the number of small washers that it took to make the wooden block move. We repeated this three times. We then did the same experiment using 2 large washers on the wooden block and then using 3 large washers on the wooden block. Our results can be seen below.

Number of Small Washers Required to Move Block

	Number of Large Washers Added to Block		
	1 Large Washer	2 Large Washers	3 Large Washers
Trial 1	4	6	10
Trial 2	5	7	9
Trial 3	5	6	10
Trial 4	4	6	10

Group B and Group C used the apparatus shown on page 11.

2. This is Group B's statement of the problem: "We tested the effect of different materials on the number of large washers added to the wooden block." Is this a clear statement of the problem Group B investigated? Explain fully why or why not.
3. Compare Group B and Group C's experiments. Which experiment, if either, do you think is better designed? Explain fully why you think so.
-



1 wooden dowel
1 wooden block
1 piece of cardboard
1 sheet of coarse sandpaper
1 sheet of fine sandpaper
1 piece of wax paper
String

20 small washers
3 large washers (for adding weight to the block)
Plastic cup to hold washers
Ruler
Masking tape
1 paper clip
Safety goggles for each student

4. A student hypothesized that changing the surface area of a box would affect the amount of friction between the box and the material it is resting on. Using the equipment listed above, design an experiment to test whether or not the student's hypothesis is correct. Your experimental design should be clear enough so that someone else could easily replicate your experiment.